



California Morbidity

***Salmonella* serotype Enteritidis in California: Current Status and Containment Efforts**

Salmonella serotype Enteritidis (SE) emerged as an important human pathogen in the eastern United States in the mid-1980s, and the outbreak soon spread to the midwest and southeast.¹ By the mid-1990s the epidemic reached western states.² Investigations in California and elsewhere of sporadic- and outbreak-associated cases of SE have repeatedly implicated dishes using shell eggs as an ingredient.³⁻⁶ SE causes an ovarian infection in poultry so that egg contents can be contaminated before egg shell formation;⁷ accordingly, disinfection of egg shells does not eliminate contamination of egg contents. SE contamination in eggs is rare, only 1% of eggs from infected chickens contain SE.⁸ For this reason pooled egg dishes are more likely than individually cooked eggs to cause SE outbreaks. Control of human SE infections requires improvement in egg production, handling, and cooking practices. This article reviews trends in the epidemiology of SE infections in California and efforts to contain the ongoing epidemic.

Definitions

For the purposes of this report, the following definitions will be used:

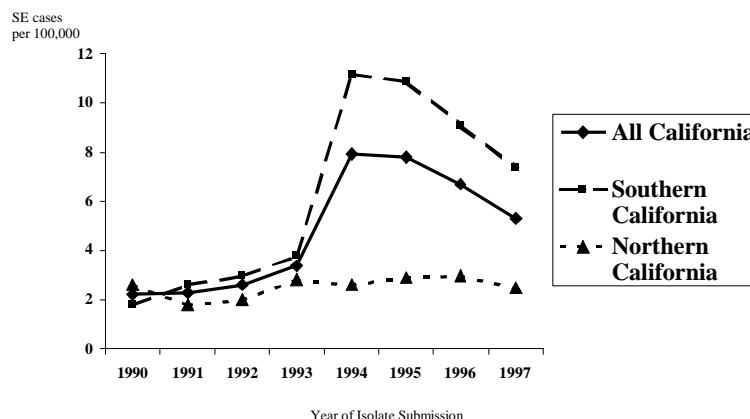
- 1) Outbreak= two or more patients with a gastrointestinal illness with a food exposure in common (e.g., they shared a meal); at least two of these patients must have laboratory-confirmed SE infection.
- 2) SE case= laboratory-confirmed case of SE infection.
- 3) Northern California= 48 counties north of the straight line formed by the northern borders of San Luis Obispo, Kern, and San Bernardino counties (~40% of the California population).
- 4) Southern California= the 10 counties south of the straight line formed by the northern borders of San Luis Obispo, Kern, and San Bernardino counties.
- 5) Confirmed vehicle= isolation of SE in a food consumed by patients **or** a statistically significant association found in a case-control study or in a cohort study of an SE outbreak.

Trends of SE infections in California

Rates

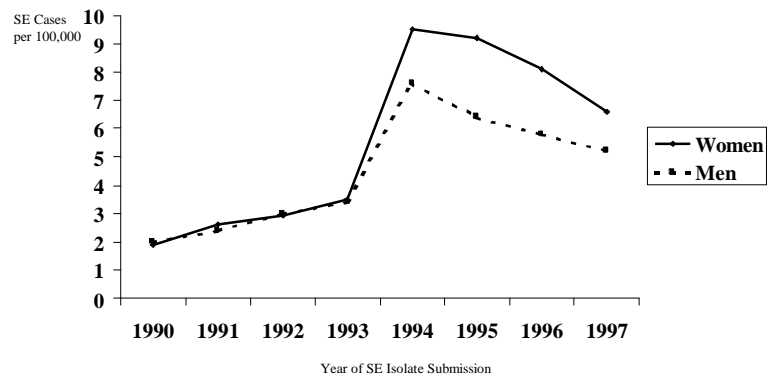
In California the rate of SE infections increased from 3.3/100,000 in 1993 to 7.9/100,000 in 1994; the rate has since decreased to 5.3/100,000 in 1997. This increase in 1994 can be attributed completely to an increase in the rate of SE infections among residents of Southern California (Figure 1). The rate of SE infections in Southern California ranged from a low of 1.8/100,000 in 1990 to a high of 11.2/100,000 in 1994; the rate has decreased each year since 1994 and, in 1997, was 7.4/100,000. In Northern California from 1990 through 1997 the rate of SE has remained between 2 to 3 cases per 100,000 population, and from 1994 through 1997 was significantly lower than in Southern California.

Figure 1. Rate of *Salmonella* Enteritidis infections by Year and Region of California, 1990-1997



The higher rate of SE infection in Northern compared with Southern California from 1994 through 1997 is constant within all 10-year age-groups and by sex. Within Southern California, from 1994 through 1997, among 20-59 year olds, the rates among women were significantly greater than those of men (Figure 2); this disparity did not occur among Northern California residents.

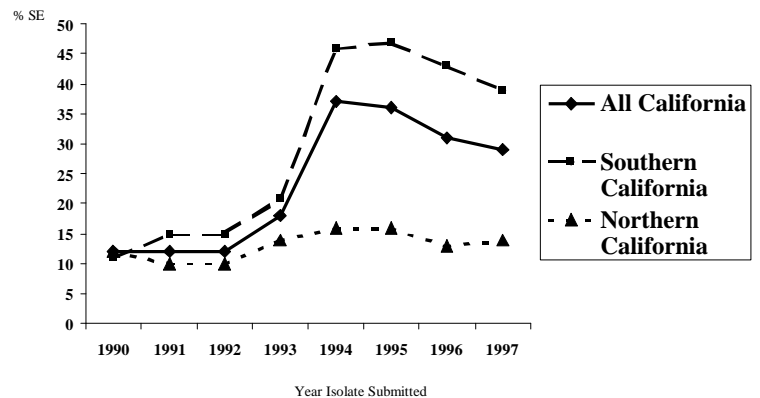
Figure 2. Rate of *Salmonella* Enteritidis (SE) Infections Among 20-59 Year Olds in Southern California by Year and Sex, 1990-1997



Proportion of all *Salmonella*

In 1990 serotype Enteritidis comprised 9.9% of *Salmonella* isolates; through 1993 this proportion remained <20%. But in 1994, SE comprised 36% of *Salmonella* isolates and since that time the proportion has remained above 25%. This increased proportion can be attributed primarily to an increase in the SE proportion in Southern California (Figure 3). In Southern California, the proportion of *Salmonella* isolates that were SE ranged from a low of 11% in 1990 to a high of 47% in 1995; in 1996 and 1997 this proportion was stable at ~40%. In Northern California, in 1990-97 the proportion of *Salmonella* represented by SE has remained stable at 10-14% and in 1997 was 14%.

Figure 3. The proportion of *Salmonella* Enteritidis among all *Salmonella* serotypes by Year and Region of California, 1990-1997



Mortality

From 1993 through 1997, SE was the underlying cause of death for at least 17 deaths (2-5 deaths per year); 14 (82%) of the deaths due to SE were among residents of Southern California. The 17 deaths are 44% of the deaths due to salmonellosis in California. These data are minimum estimates of deaths due to SE and salmonellosis since, by definition, underlying cause of death data do not include salmonellosis if listed as a "contributing cause" on death certificates.

Phage type 4

In recent years, Northern and Southern California have differed substantially in the proportion of phage type 4 (PT4) among SE isolates. PT4 has caused an epidemic in European countries but, until recently, has rarely been identified in the United States. Investigations of SE PT4 in Europe suggest that once this phage type is introduced in chicken flocks, there is a tendency to spread rapidly; human outbreaks result and PT4 then persists as the predominant strain in both chickens and humans. In California, data are available for phage typing of sporadic SE cases for the years 1990, 1994, and 1996. In 1990, the proportions of SE isolates comprised by PT4 in Southern and Northern California were similar (29% vs. 35%). However, in 1994 the proportion of PT4 isolates in Southern California rose to 89% while that in Northern California was 50%. In 1996 the proportion

of SE isolates represented by PT4 was 59% in Southern California but was only 13% in Northern California. Similarly a higher proportion of SE outbreaks in Southern California have been due to PT4 than outbreaks in Northern California. In Southern California isolates from 26 outbreaks were tested, 81% (21 outbreaks) were PT4. In contrast only 33% (1 of 3 tested) of SE outbreaks in Northern California were due to PT4.

SE Outbreaks

From 1993 through 1997 there were 53 SE outbreaks reported in California; 48 (90%) of them were in Southern California. Table 1 shows the increase in outbreaks in Southern California that began in 1994 and persisted through 1997. Outbreaks were associated with meals eaten at commercial establishments (69%), congregate living residences (10%), and private homes (21%).

Table 1. *Salmonella* Enteritidis Outbreaks by Region and Year in California, 1993-1997.

Region	1993 Outbreaks # (%)	1994 Outbreaks # (%)	1995 Outbreaks # (%)	1996 Outbreaks # (%)	1997 Outbreaks # (%)	Total Outbreaks # (%)
Northern California	1 (20)	1 (11)	2 (17)	0 (0)	1 (8)	5 (10)
Southern California	4 (80)	8 (89)	10 (83)	14 (100)	12 (92)	48 (90)
Total	5	9	12	14	13	53 (100)

Northern California= the 48 counties north of the straight line formed by the northern border of San Luis Obispo, Kern, and San Bernardino counties. Approximately 40% of the California population resides in Northern California. Southern California= the 10 counties south of the straight line formed by the northern border of San Luis Obispo, Kern, and San Bernardino counties. Approximately 60% of the California population resides in Southern California.

Of the 53 outbreaks, 22 (42%) had a confirmed vehicle identified. Of the confirmed vehicles, 18 (82%) were eggs or egg-containing dishes. Of these egg-containing dishes, 44% were traditionally prepared egg dishes (such as scrambled eggs or french toast), 6% were meant to have been fully cooked (baked egg dishes such as lasagna or ziti), 11% were gently heated sauces (bearnaise sauce, hollandaise sauce), and 39% were foods that contained raw eggs (such as mayonnaise and homemade ice cream). The investigation of many of these outbreaks revealed that pooled eggs were incompletely cooked. In most outbreaks there was documentation of egg handling practices that would contribute to SE growth, such as storage of shell eggs, or holding of pooled raw or cooked eggs at room temperature. Non-egg-containing confirmed vehicles included green salad, potato salad (without egg), cake, and turkey served with mashed potatoes. The green salad was suspected by those investigating the outbreak to have been cross-contaminated by the same knife used to cut raw chicken without subsequent washing. Both the cake frosting and the mashed potatoes were suspected to have been due to cross-contamination of those items by raw eggs. Among outbreaks with unconfirmed vehicles, 80% involved meals with eggs or egg dishes.

SE Control in California

The California Department of Health Services and the California Department of Food and Agriculture have adopted both short-term and long-term control measures. One short-term control measure involves the identification of SE-infected egg ranches by conducting traceback investigations from SE outbreaks and then diverting their eggs to pasteurization until eggs consistently test negative for SE. Long-term control measures include the implementation of a voluntary California Egg Quality Assurance Plan (CEQAP) in 1994 and the enactment of a California law requiring that eggs be refrigerated during transport and delivery in January 1998.

The CEQAP was initiated in 1994 by the egg industry. This voluntary program for farms and processing facilities emphasizes safe production and processing practices that include biosecurity, rodent control, and flock health management. Farms representing 95% of egg production in California currently participate in this plan.

In June 1996, several state and federal government agencies (the U.S. Food and Drug Administration, California Department of Health Services, and California Department of Food and Agriculture) and the CEQAP participants signed a memorandum of understanding (MOU) to facilitate egg traceback investigations and testing for SE on implicated farms. Since the initiation of this MOU, 6 outbreaks have had traceback investigations performed. Four (67%) of the environmental investigations of implicated farms revealed SE contamination and SE was identified in eggs from two of those implicated farms. Of the four farms with SE found in their environment, all were located in Southern California and two were members of CEQAP. Farms with SE-contaminated eggs diverted their eggs to pasteurization.

Discussion

There was a dramatic increase in *Salmonella* serotype Enteritidis in California in the 1990s and California now bears a disproportionate burden of the nation's SE disease. In 1997, 22% of the nation's reported SE cases and 29% of the outbreaks were in California which has only 12% of the U.S. population; 90% of SE PT4 outbreaks in the U.S. were from Southern California (CDC, unpublished data). There has been a steady decrease in the rate of SE infections in California since 1995; this decrease could be due to improved control of the source of SE (e.g., control of SE on egg farms). However, the SE rate in Southern California is still quite high (7.4 per 100,000) compared with the rate of SE in the United States exclusive of California (2.6 per 100,000). In addition, in California, the rate of infection from all serotypes of *Salmonella* has decreased since 1995 so that the proportion of *Salmonella* isolates that are SE has decreased only minimally. In 1997 SE represented close to 40% of *Salmonella* isolates among residents of Southern California. This proportion is much higher than in Northern California (14%) and the U.S. national average (22%). The high rate of SE infection and the high proportion of SE among *Salmonella* infections suggests that the SE epidemic is not yet well controlled in Southern California.

The most likely reason for the emergence of the SE epidemic in California is an increase, starting about 1994, in the exposure of Californians to SE-contaminated eggs, especially PT4. Transovarial transmission or penetration of SE through the shell of the egg is likely to be the major ways that eggs become contaminated in California. In traceback investigations conducted in California, the source was found to be grade A or AA shell eggs with clean uncracked shells in all but one outbreak. In one outbreak investigation, a culture of **shells** from the epidemiologically implicated eggs did **not** grow SE but a culture of the **egg contents** did grow SE; this SE isolate had the same rare plasmid profile as that recovered from patients in the outbreak.⁶

Egg-associated outbreaks of SE could also be caused by infected food handlers who contaminate egg-containing dishes. However, if food handlers were a major cause of *Salmonella* contamination of eggs, any number of the >2,000 *Salmonella* serotypes would be represented in egg-associated outbreaks, whereas >85% of egg-associated *Salmonella* outbreaks in the U.S. are caused by one serotype, SE (CDC, unpublished data). In California, SE has caused all 18 egg-associated *Salmonella* outbreaks since 1990. Similarly, if food handlers were the cause of SE outbreaks, then any number of foods could be contaminated and cause disease, but >85% of SE outbreaks with a confirmed vehicle in California and in the U.S. are associated with egg dishes.¹

The significantly higher rate of SE infections in Southern California, compared with Northern California, is noteworthy. Possible reasons for the difference in rates in the two regions include: 1) there might be a higher proportion of SE-contaminated eggs sold in Southern California (i.e., a difference in exposure to SE contaminated eggs), 2) there might be environmental differences, such as vector populations on ranches that supply eggs to Northern vs. Southern California, 3) there might be higher heat resistance in SE strains contaminating eggs produced in Southern California, 4) the population in Southern California may be more susceptible to disease than that in Northern California, and 5) there might be more high-risk egg handling practices (such as pooling of eggs) in Southern California (i.e., a difference in contributing factors that amplify contamination) than in Northern California. While the first three reasons are plausible the latter two are unlikely.

The source of eggs for Southern California is different from that for Northern California. Ninety-five to 99% of eggs produced in Southern California are distributed in Southern California and 95-99% of eggs produced in Northern California are distributed to Northern California (Jill Snowdon, Director of Food Safety Programs, Egg Nutrition Center, personal communication). Given the differences in climatic conditions in Southern vs. Northern California, there may be different vector populations on egg ranches in these regions. In addition, Southern California receives 60- 80% of eggs that are imported into California from other states while Northern California receives 20-40% of the imported eggs (California Department of Food and Agriculture, Egg Quality Control Board, unpublished data). The difference in egg sources for the two regions probably also explains why the majority of SE isolates and outbreaks from Southern California are PT4 but this phage type does not predominate in isolates or outbreaks from Northern California. PT4 SE infection has been documented in outbreak-associated and non outbreak-associated egg ranches in Southern California,⁹ but this phage type has not yet been reported from Northern California farms. The predominance of PT4 in Southern California may also contribute to the higher rates of SE infection in that region since PT4 is known to be both more heat-resistant than other strains of SE¹⁰ and more invasive for young chickens (facilitating transovarial transmission).¹¹

A difference in the susceptibility of human populations between Northern and Southern California is unlikely since the difference in SE rates remains after adjustment for age and sex; also, the prevalence of AIDS, a salmonellosis risk factor, is similar in Northern and Southern California (James Creeger, informal communication). Finally, there is no evidence to suggest that egg preparation practices are substantially different between populations living in Northern and Southern California. A survey of restaurants in California did not suggest any differences between Northern and Southern California in egg handling practices (unpublished data, Robert Murray, CDHS).

Striking is the higher rate of SE among adult women, compared with men, in Southern California. Women may be exposed to raw eggs to a greater extent than men either through exposure while cooking or possibly by consuming raw egg as a supplement to fruit drinks. The reasons for the difference in sex-specific rates in adults in Southern California merit investigation.

Conclusion and Recommendations

There is an ongoing epidemic of SE in California, primarily in Southern California that needs to be controlled. This will require multi-pronged efforts: 100% of egg ranches should be enrolled in the CEQAP, and consumers and food service providers need additional education to adhere to safe egg handling and cooking practices. Egg ranches should endeavor to prevent the introduction of SE by following guidelines in the California Egg Quality Assurance Plan and to routinely test the ranch environment for SE contamination. If SE is found, egg ranches should promptly take effective steps to eliminate it. Adherence to California's law requiring eggs to be refrigerated will limit bacterial growth but will not eliminate it. For this reason, consumers and restaurants should reduce factors that contribute to the proliferation of SE by following the egg handling guidelines listed in Table 2. Persons with health conditions that place them at extra risk for complications from SE infections (e.g., the young, the elderly, the immunocompromised, or those with reduced stomach acid) should refrain from eating undercooked unpasteurized eggs (as they should avoid consuming all raw animal products). Hospitals, nursing homes, and other institutions that provided food to elderly or immunocompromised persons should use ONLY pasteurized eggs for egg dishes.

Table 2. Recommendations for Reducing the Risk of *Salmonella enteritidis* from Shell Eggs

1. Shell eggs should be kept refrigerated and maintained at an internal temperature of 45 degrees F or below until sold or used.
2. Only clean uncracked eggs should be used.
3. Hands should be washed with soap and water before and after using shell eggs.
4. All blenders and utensils that come in contact with raw eggs should be dismantled and washed before using them again.
5. Raw eggs should not be used as an ingredient in the preparation of uncooked or gently heated, ready-to-eat menu items such as Caesar salad dressing, hollandaise or bearnaise sauce, mayonnaise, eggnog, ice cream, and egg-fortified drinks.
6. Shell eggs should not be pooled if the pooled eggs are to be held > 2 hours before or after cooking (e.g. scrambled eggs, omelets, French toast, Monte Christo sandwiches, chocolate mousse, and meringue).
7. Individually prepared eggs and pooled eggs should be cooked to 140 degrees F or above; both the yolk and egg white should be firm and not runny.
8. Cooked eggs that require holding before service should be held at an internal temperature of 140 degrees F or above.
9. Pasteurized eggs should be substituted for shell eggs for all egg recipes that require uncooked or lightly heated eggs.

Adapted with permission from: Mohle-Boetani JC, Werner SB, Abbott S, et al. Salmonella enteritidis infections from shell eggs: outbreaks in California. West J Med 1998; 169:299-301.

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